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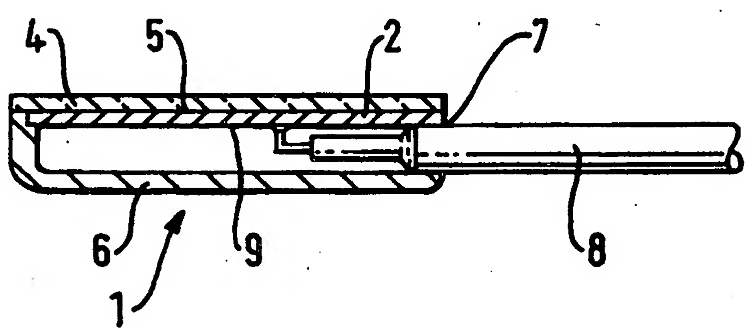
(54) Title: MATCHING DEVICE FOR A MULTI-FREQUENCY ANTENNA

(57) Abstract

An antenna coupling unit (1) for use with a dual-frequency glass-mount antenna (3) incorporates additional circuitry in the form of suitably shaped patterns of conductive cladding material (10, 11 and 13 to 20) to provide resonance at both antenna frequencies.



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Matching device for a multi-frequency antenna

The present invention relates to a matching device for a screen mounted multi-frequency antenna, particularly, although not exclusively for use with a cellular telephone.

In our earlier U.K. Patent Application No. 9700859.3 we described a dual-frequency antenna for use with PCN (E-Net) and GSM (D-Net) cellular telephony networks. Such an antenna which utilised a phasing coil to separate two individual radiating elements could be used with a conventional vehicle body mount. However, such an antenna could not be used effectively on a glass mount base with a conventional matching device.

Matching devices for use with glass mount bases and which provide the necessary compatibility between an antenna and a telephone within a vehicle are known. In particular, European Patent No. 0 456 350 which is in the name of the present Applicants, describes just such a matching device or coupling unit for use with a screen mounted antenna. The unit includes a circuit board substrate of suitable dielectric material having patterns of conductive cladding material on both surfaces thereof to provide the requisite matching and balancing functions. However, the unit is suitable for use with a single frequency antenna.

It is therefore an object of the present invention to provide a glass mount coupling unit suitable for use with a multi-frequency antenna and a cellular telephony antenna in particular.

According to the present invention there is provided a glass mount antenna coupling unit of the type above described for use with an antenna operating at more than

one frequency, characterised in that in addition to providing a capacitive coupling to a base mounting of the antenna, the conducting material is so shaped and arranged to form a circuit, including high-pass and low-pass filters, which is resonant at each said frequency.

The coupling unit is intended to provide the maximum power transfer at the frequencies of interest. Thus the circuit may contain one or more of the following circuit elements. Firstly, passive printed circuit filters relying on a combination of inductive and capacitive tracks to produce frequency selective circuits. Secondly, strip line resonators formed of stepped impedance, direct and parallel coupled resonators, stub loaded configurations and grounded stubs (direct coupled) structures.

In order to aid in understanding the invention a specific embodiment thereof will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a sectional side view of a coupling unit in accordance with the invention;

Figure 2 is a view of the circuit board of Figure 1, from the screen side of the board;

Figure 3 is a view of the opposite side of the circuit board;

Figure 4 is a superimposed view of both sides of the circuit board from the screen side; and

Figure 5 is an equivalent circuit diagram of the coupling unit shown in the above figures;

Figure 6 is a sectional side view of the separate components of a multi-frequency antenna for use with the coupling unit of Figures 1 to 5;

Figure 7 is a cross-sectional side view of the antenna of Figure 6 at an intermediate stage of assembly;

Figure 8 is a similar view to that of Figure 7 at later stage of assembly;

Figure 9 is a similar view a still further stage of assembly;

Figure 10 is side view of the assembled antenna of Figure 6 with a panel mount base; and

Figure 11 is an exploded view of a glass-mount base for the antenna of Figure 6.

Referring to the Figures 1 to 5, a coupling unit 1 in accordance with the invention comprises a circuit board substrate 2 of any suitable insulating material, provided on both sides with conductive cladding elements. These elements are so configured to define a set of capacitive, inductive and resistive elements which cause the unit to resonate at both GSM and PCN frequencies whilst providing capacitive coupling to the base of a dual frequency antenna 3.

Referring to Figure 1, the unit 1 is mounted on a suitable dielectric such as a glass screen 4 of a vehicle (not shown) with a first side 5 of the substrate 2 adhesively secured thereto. The substrate 2 is positioned within a conductive housing 6 which incorporates an aperture 7 for receiving a coaxial cable 8 to be coupled to the unit 1. The cable 8 is soldered or otherwise physically secured to the substrate 2 on its opposite or second side 9. The dual frequency antenna 3 is adhesively secured on the opposite side of the screen 4 in a facing relationship to the first side 5 of the substrate 2.

Clearly, the precise arrangement of the cladding elements making up the coupling and resonant circuitry depends on the material used for the substrate 2 and the frequencies at which resonance should occur. It will be therefore understood that various alterations and

modifications may be made to the arrangement as illustrated without departing from the scope of the invention.

Consequently, the circuitry may be best understood by reference to the equivalent circuit diagram of Figure 5, and be referencing the various capacitive and inductive elements to corresponding physical elements, including the cladding, shown in Figures 1 to 4:

L1,L2	-	inductance formed by tracks 10,11 on the substrate 2.
L3	-	inductance formed by the feed 20 from the inner conductor of the coaxial cable 12.
L4,L6	-	inductance formed by overlapping elements 13 and 14 on opposite sides of the substrate.
L5	-	further inductance formed by overlapping elements 13 and 14.
C1	-	capacitance formed by overlapping elements 13 and 14.
C2	-	capacitance formed by overlapping elements 15 and 14.
C3	-	capacitance formed by overlapping elements 16 and 14.
C4	-	further capacitance formed by overlapping elements 15 and 14.
C5	-	capacitance formed by overlapping elements 17 and 14.
C6,C7	-	capacitance formed by elements 18,19 bordering element 14.
C8	-	distributed capacitance formed by the metallic enclosure 6.
C9	-	capacitance formed across the screen 4 of the vehicle.

It is to be understood from the above that the fields from all the conducting elements contribute to provide the matching mechanism to the antenna. Thus it will be noted from the equivalent circuit that some of the cladding elements react to form different reactive values in different parts of the circuit.

Further points to be noted from the above are that the inductance of the feed point can be minimised, where necessary by introducing an un-grounded relief hole 21 in the substrate 2 which creates counter-capacitance. Furthermore, although the gap 22 between elements 13 and 15 is shown as being tapered a constant width gap has been found to perform adequately in practice. Additionally, by changing the length of the element 19 the resonance of the circuit may be altered.

Referring to the Figures 6 to 10, the antenna 101 comprises a combined bottom crimp terminal and first radiating element 102, a metallic helically wound spring or phasing coil 103, a top crimp terminal 104, and a stainless steel rod or second radiating element 105. The bottom crimp terminal 102 is formed with an end connector suitably threaded or otherwise formed for connection to a base 107 mounted on the roof 108 or other body panel of a vehicle. Antenna signals are fed to terminals (not shown) within the base 107 which terminals connect to a coaxial or other suitable antenna lead 106.

The antenna is assembled in a series of stages as set out in Figures 7 to 9 of the drawings. Firstly, one free end 109 of the coil 103 is crimped to a crimp point 110 in the bottom crimp terminal and first radiating element 102. The other free end 101 of the coil 103 is then crimped within the top crimp terminal 104 leaving space within the terminal 104 for the second radiating element 105 to be

similarly inserted and crimped in place. To complete the basic assembly, a pressed butterfly 112 is secured to the remaining free end 113 of the element 105 to facilitate plastics material encapsulation.

Turning to Figures 8 and 9, these show a two step moulding process, in which firstly (Figure 8) a black engineering plastics material moulding 114 is formed around the coil 103. A second later moulding stage follows (Figure 9), in which a black plastics material moulding 115 is formed around the bottom crimp terminal 102 and the previously encapsulated coil 103,114. Such a two stage process enhances the surface finish of the completed moulding which otherwise might reveal the contours of the encapsulated coil. A separate end plastics material end tip 116 is moulded around the butterfly 112 at the free end of the element 105.

An assembled antenna is shown in Figure 10 attached to the base 107 of the panel mount type on the vehicle containing the cellular and/or GPS equipment. In a variant intended for use with the coupling unit 1, the antenna (not shown) is secured by a threaded connection to a glass-mount base 207, as shown in more detail in Figure 11. As is clear from Figure 11, no circuitry is required in the base 207 to provide the capacitive link to the coupling unit 1 as the bracket 208 provides the necessary capacitance.

It will be appreciated by one skilled in the art that the above antenna could, instead of being made up of several separate elements, be formed as a unitary item which would advantageously increase the performance and simplify assembly of the antenna. However, the skilled person would also recognise the difficulty in manufacturing such an antenna and in particular the difficulty of

ensuring that the first and second radiating elements remain coaxial with the phase coil.

Finally, it should be noted that any reference to a glass in the above description should be taken to refer equally to a composite or plastics material body panel which exhibits dielectric properties.

Claims:

1. An antenna coupling unit for capacitively coupling to a multi-frequency antenna mounted on a dielectric such as windscreen, the unit including a substrate of suitable dielectric material having patterns of conductive cladding material on both surfaces thereof to provide antenna matching and balancing and wherein the conducting material is further shaped and arranged to form a circuit, including high-pass and low-pass filters, which circuit is resonant at a plurality of antenna operating frequencies.

2. A coupling unit as claimed in Claim 1, wherein the circuit is resonant at both GSM and PCN frequencies.

3. A coupling unit as claimed in Claim 1 or Claim 2, wherein the conducting material includes a set of inductive and capacitive tracks.

4. A coupling unit as claimed in any preceding Claim, wherein the conducting material includes a set of strip line resonators.

5. A coupling unit as claimed in any preceding Claim, wherein the substrate includes an un-grounded relief hole.

6. A coupling unit substantially as described herein with reference to Figures 1 to 4 and Figure 5 of the accompanying drawings.

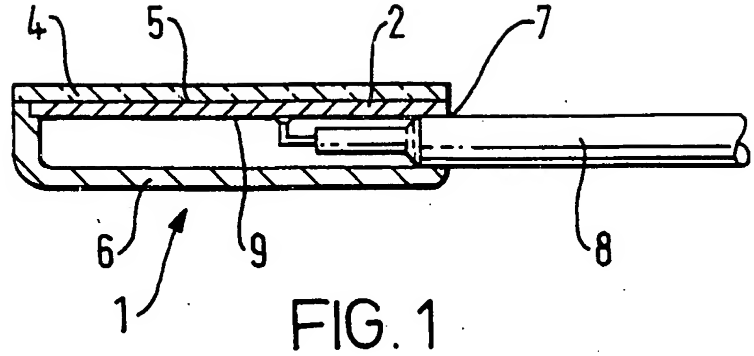


FIG. 1

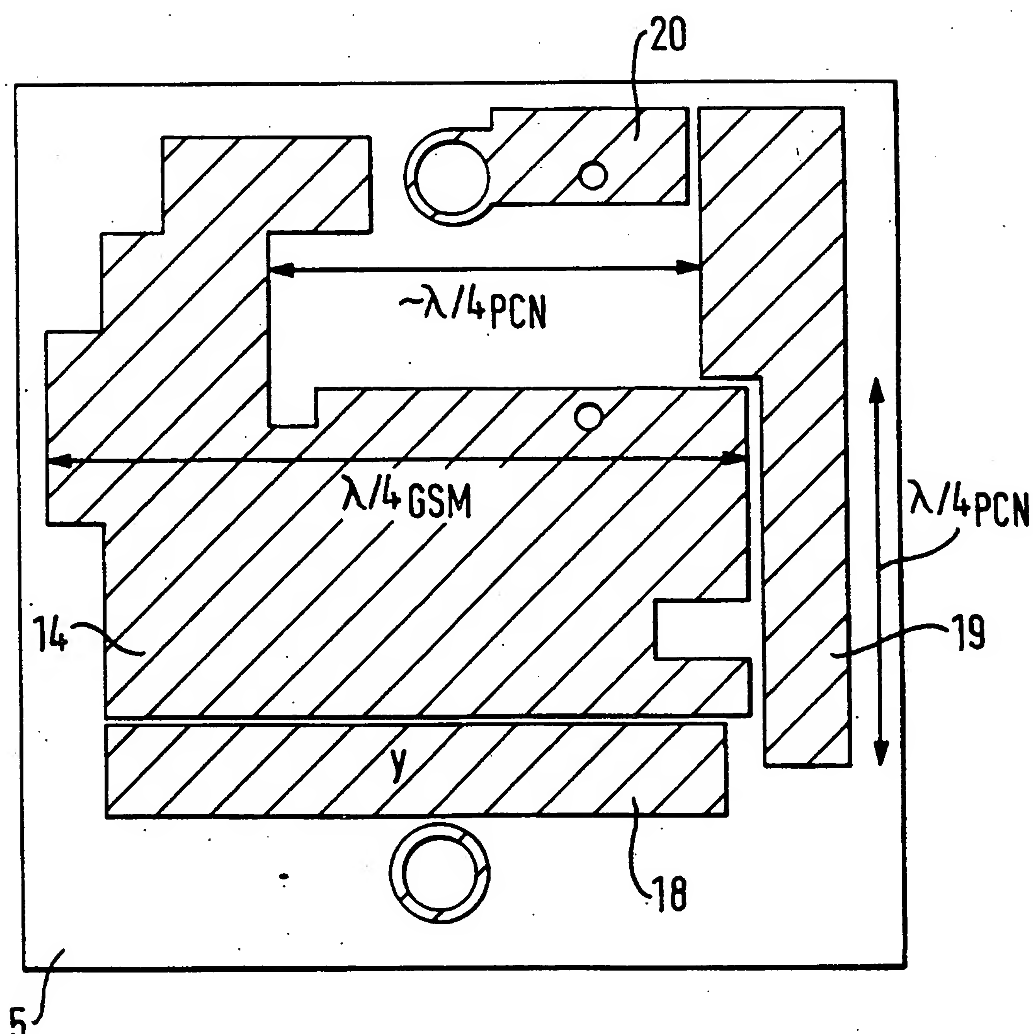


FIG. 2

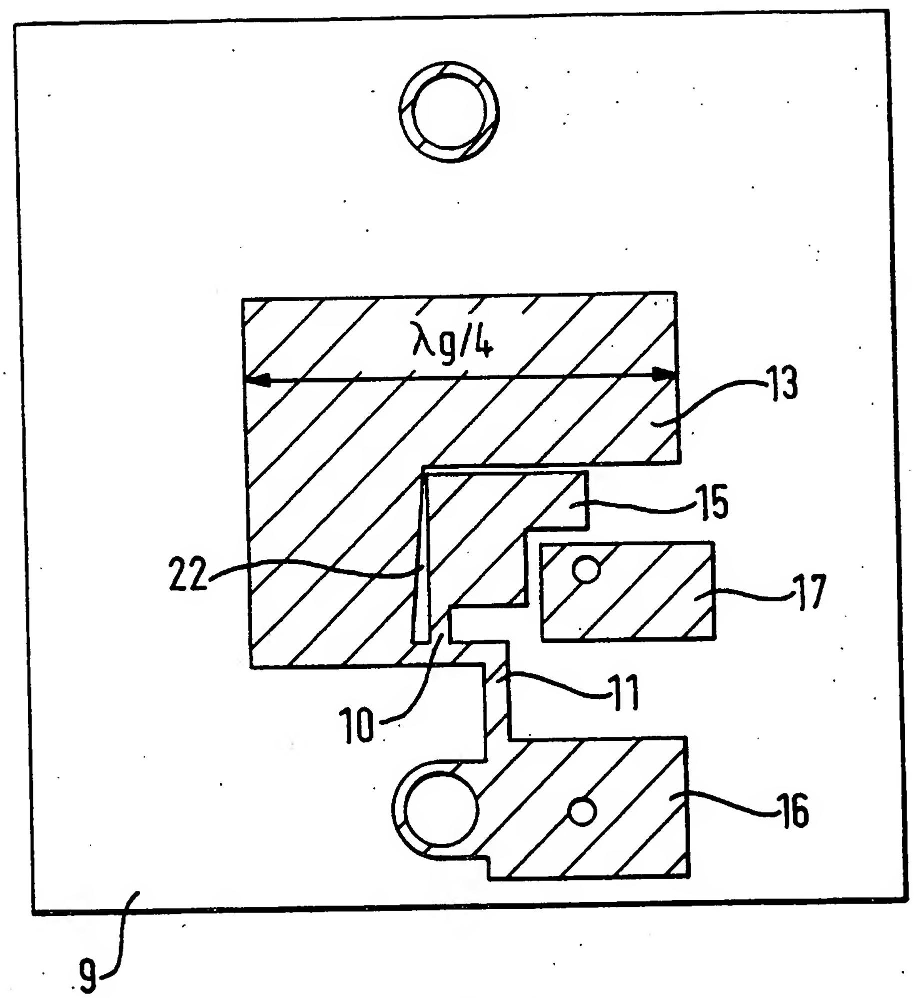


FIG. 3

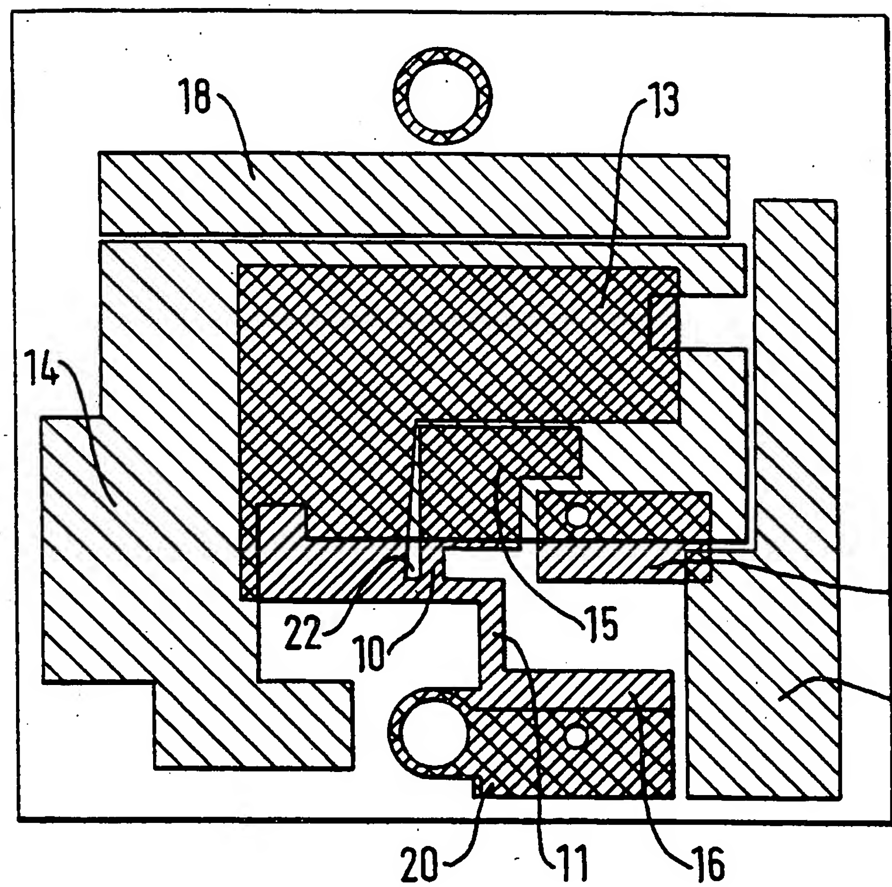


FIG. 4

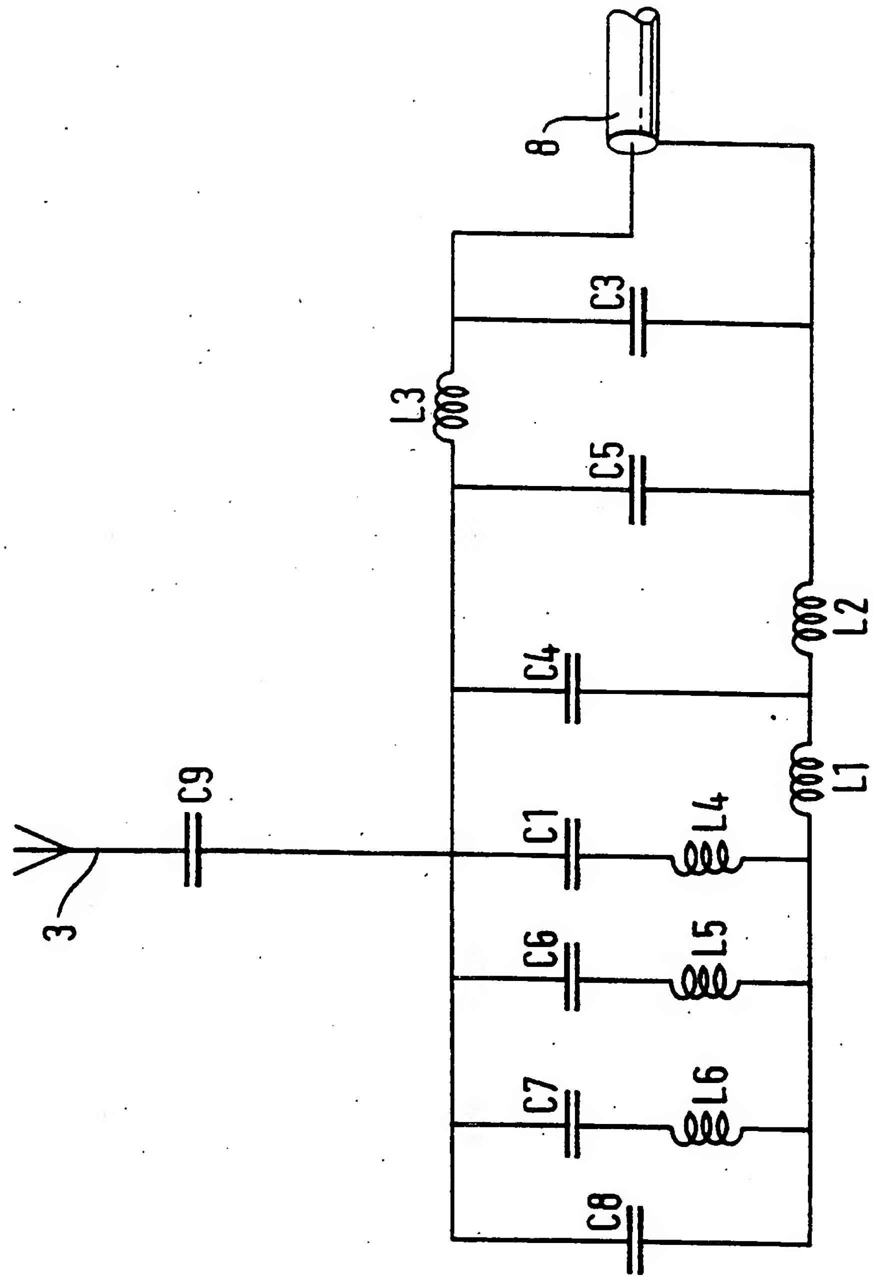


FIG. 5

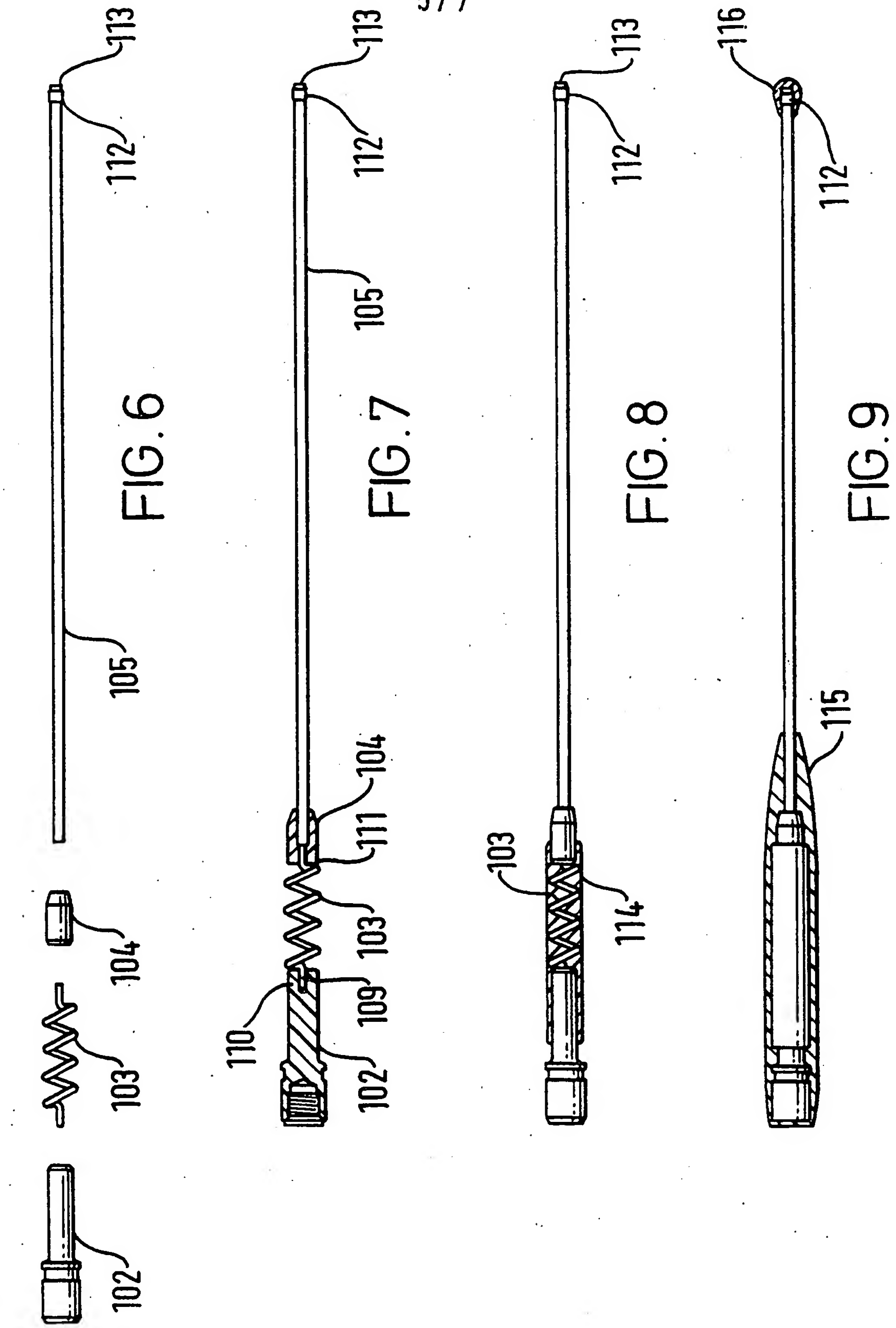


FIG. 6

FIG. 7

FIG. 8

FIG. 9

FIG. 10

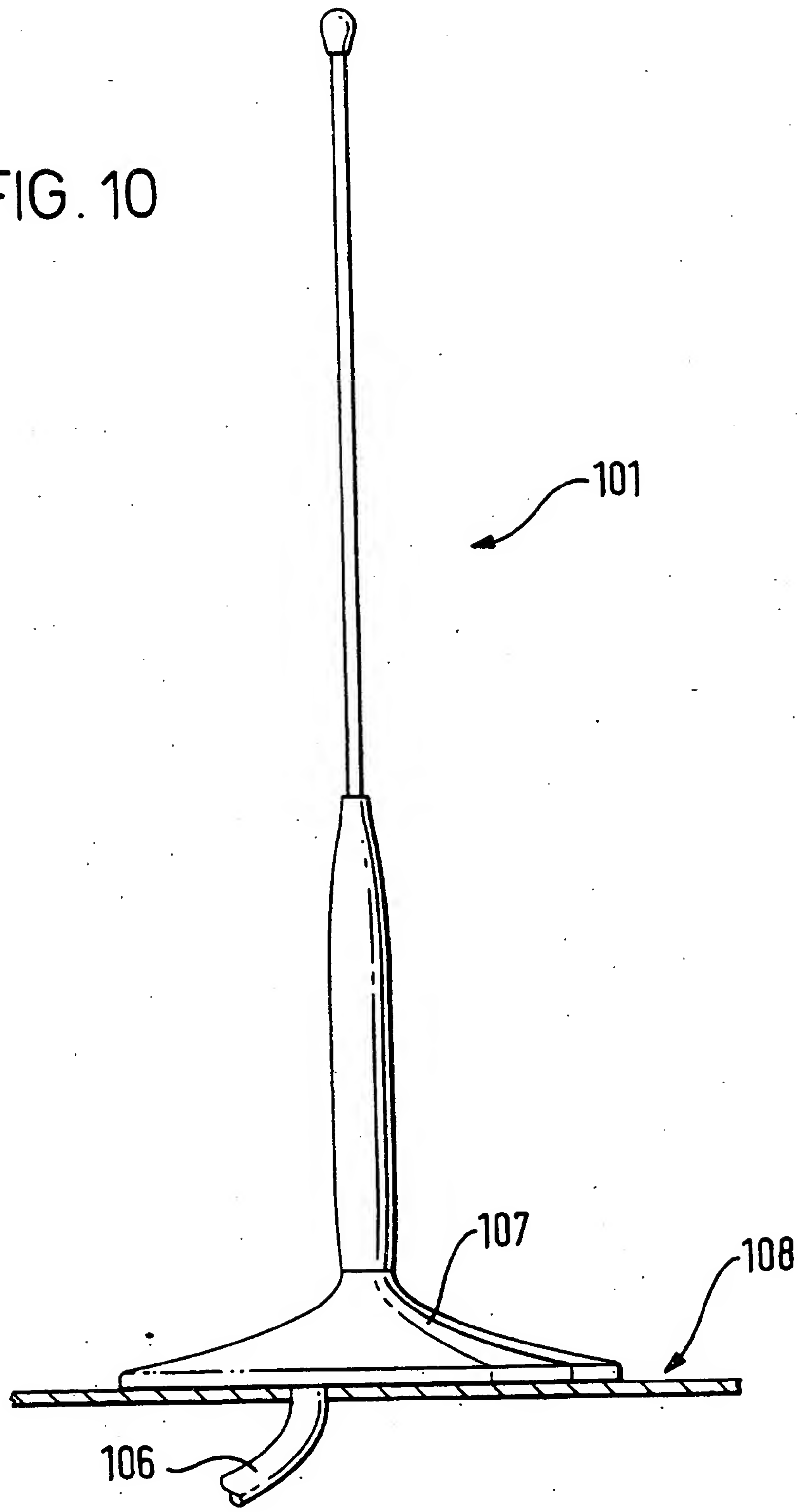
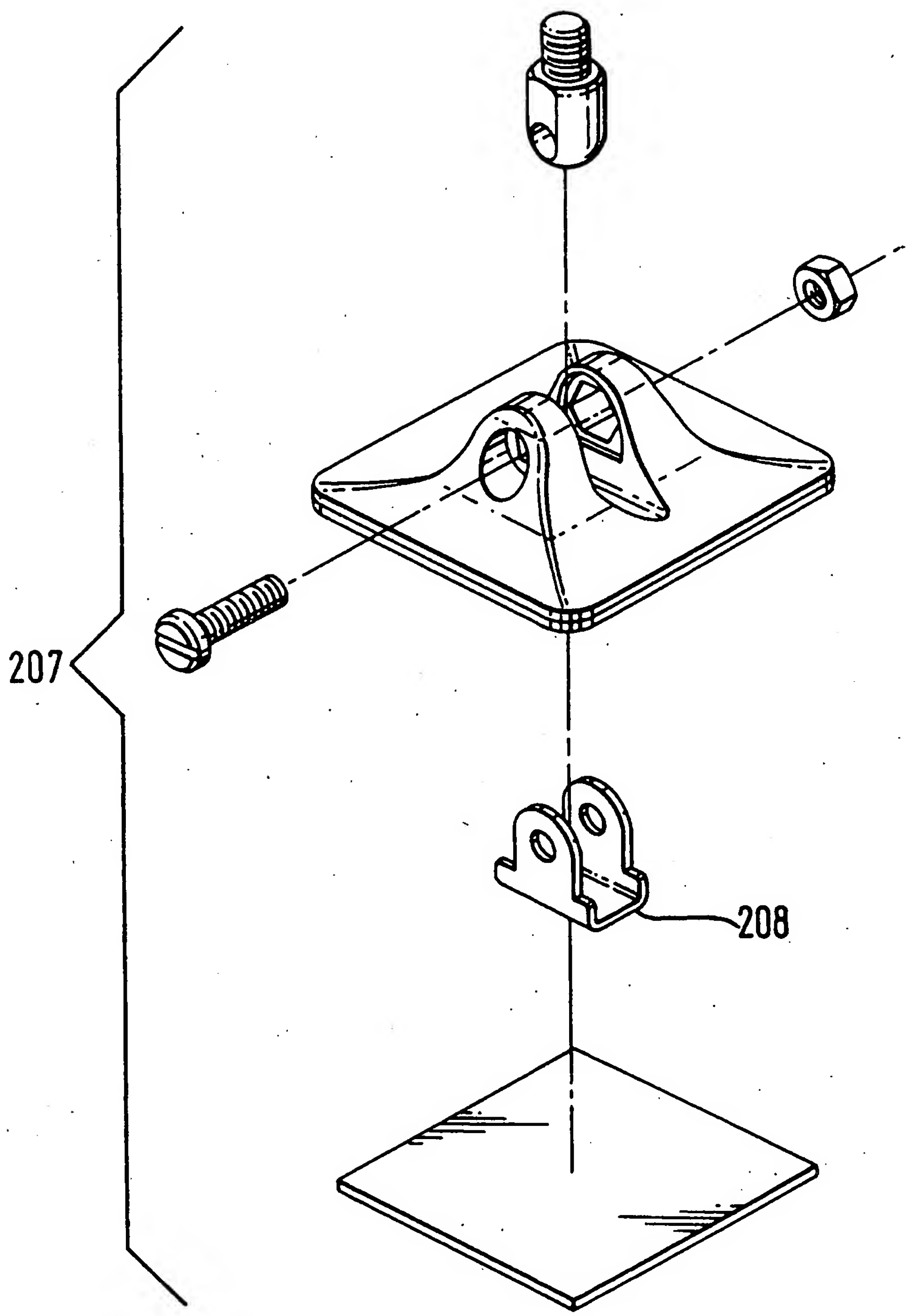


FIG.11



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/01220

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01Q1/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01Q H01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 5 278 572 A (HARADA TAKUJI ET AL) 11 January 1994 see the whole document ---	1-3
X	US 5 557 290 A (WATANABE HIRONOBU) 17 September 1996 see column 6, line 27 - column 9, line 65; figure 10 ---	1-3
Y	DE 93 09 897 U (MAY HANS GEORG) 23 September 1993 see page 4, line 9 - page 6, line 3; figures 6,7 ---	1-3
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[X] Further documents are listed in the continuation of box C.

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Information on patent family members

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